Filling and Emptying of the Alimentary Tract of Meal-Fed Broiler Breeder Hens

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ABSTRACT For evaluation of the filling and emptying of the alimentary tract, broiler breeder hens were cooped and processed over a 2-d period. Hens were fed at 0600 h on d 1 and after access to feed for 0, 2, 4, and 6 h were placed into coops. Half of the hens from each pen were either immediately processed or were held in coops overnight and processed the following morning, d 2. The alimentary tract was excised from the carcass and then separated and weighed in three segments: the crop, proventriculus and gizzard, and intestines. Hens processed on d 1, after access to feed for only 2 h, had attained maximum intestine weight (176 g), but not until after access to feed for 6 h were peak crop weight (95 g) and peak weight for the proventriculus and gizzard (78 g) attained. Hens processed on d 2 did not differ in crop (12 to 14 g) or intestine (140 to 162 g) weight, but proventriculus and gizzard weights were significantly lower for hens not fed on d 1 prior to cooping (54 g) compared with hens fed on d 1 and cooped after 2, 4, or 6 h (62 to 63 g). However, hens processed on d 2 had proventriculus and gizzard weights that were the same as for those hens processed on d 1 and cooped at 0 h (63 g). Clearance of ingesta from the crop, proventriculus and gizzard, and intestines readily occurred while hens were held overnight without access to water.

(*Key words*: broiler breeder, crop, intestine, meal feeding, proventriculus and gizzard)

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INTRODUCTION

The presence of ingesta retained in the crop or the digestive tract of poultry at the time of processing can lead to bacterial contamination of the carcass from leakage or upon rupture of the tract (Hargis, et al., 1995; Ramirez et al., 1997; Hinton et al., 2000; Byrd et. al., 2002). Crop volume increases with body size and therefore is typically greater in males than females and is greater in broilers than in Leghorn strains (Wehner and Herrold, 1982). Emptying of the alimentary tract after a meal is mainly dependent on time (Wabeck, 1992). The muscular contractions that lead to crop emptying are initiated through the left vagus nerve, and their frequency increases with the length of time since the last feeding (Sturkie, 1976). However, reports in the literature have described slower crop emptying patterns when broilers were fed meal and then held in coops or placed in the dark (Summers and Leeson, 1979; May et al., 1988; May and Deaton, 1989). Broiler breeder hens are frequently transported and held prior to processing over a period that exceeds 24 h due to the sparsity of processing facilities for breeder hens. There is a void of information recommending when the last feeding should occur for broiler breeder hens in order to minimize alimentary tract contents during processing and maintain yield. Table egg producers have the option of withholding feed from hens in cages the last few days in order to obtain additional eggs while emptying the alimentary tract of the hens prior to cooping for processing. The feasibility of this management procedure for broiler breeder hens has not been documented and may not be profitable if a significant amount of egg or litter eating occurs, because hens are not housed in rollout egg laying cages.

Occasionally broiler breeder hens are processed with large amounts of ingesta retained in the crop. It has not been determined under what circumstances this situation occurs. Typically, when crops contain significant amounts of ingesta they are distended and easily rupture during evisceration, spreading ingesta and bacterial contamination over the carcass surface. There are incidences when hens are cooped, transported, and processed on the day they were last fed. The experiments reported in this manuscript were conducted to determine the filling and emptying pattern of the crop, proventriculus and gizzard, and intestines when broiler breeder hens were cooped at 0, 2, 4, and 6 h access to a single daily limited meal.

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MATERIALS AND METHODS

Housing and Feeding of Broiler Breeder Hens

Breeder hens were sampled twice from 1 flock at 48 wk (flock A) and 70 wk (flock B) and from a second flock at 44 wk (flock C); all hens had been raised in environmental-type houses in floor pens by J. L. Wilson at the University of Georgia. Two weeks prior to processing, selected hens were determined to be in lay by vaginal eversion, BW was obtained, and a numbered leg band was applied. Hens were then placed into 4 floor pens (14 hens / pen, 2.4 × 3.6 m) that were covered with clean wood shavings. The photoperiod remained at 14 h of light per day, and hens were maintained on a nonmedicated, corn-soybean meal-based, mash laying diet (2,911 kcal ME / kg, 16.5% CP, 3.0% Ca). During these 2 wk, hens were provided 133 g of feed per hen per day that was placed into a single tube feeder per pen at 0600 h each day. Initial individual hen BW was attained 2 d before processing (prior to feeding that day) and averaged 3.4, 3.9, and 3.7 kg for hens from flocks A, B and C, respectively.

On d 1 of processing, all 14 hens in a pen were placed into 2 plastic coops (for processing on d 1 or d 2) by treatment group at 0, 2, 4, and 6 h after the 0600 h feeding. The hens cooped at 0 h were last fed the previous morning at 0600 h. Hens had ad libitum access to water and litter prior to cooping. One coop of hens per treatment group was immediately transported less than 2 km to the pilot plant at the research facility. The remaining cooped hens were held in the concrete hallway and subject to continuous overhead lighting. The next morning these hens were transported to the pilot plant for processing.

Processing Procedures

Immediately following cooping and transport, hens by treatment group were removed from the coop, hung in shackles, and stunned (head to shanks) at 15 V pulsated DC (500 Hz) using an in-line Simmons[2] SF-7000 prestunner cabinet. They were killed with a Simmons SK-5 automated knife and bled for 120 s. Carcasses were scalded at 56.7°C for 120 s in a scalder containing approximately 2,000 L of water and defeathered with a commercial Gordon-Johnson[3] single-pass picker with 5 banks of picker fingers for approximately 30 s. After being defeathered, heads and shanks were removed with hand shears. This procedure was followed at 0, 2, 4, and 6 h after the 0600 h morning feeding. On d 2, the above processing procedures were followed at 30-min intervals starting at 0800 h. Each treatment group consisted of 7 hens that were cooped after 0 (24), 2, 4, and 6 h after the 0600 h feeding and were processed in sequence after being held in coops for 26, 24.5, 23, and 21.5 h, respectively.

[2]Simmons Engineering Company, Dallas, GA.
[3]Johnson Food Equipment Co., Kansas City, KS.

Evisceration

After the cloaca was clamped externally at the vent with a hemostat, the abdominal cavity was opened from the keel to the vent. The proventriculus was located and the thoracic esophagus was clamped to retain the contents within the proventriculus, and then the esophageal-proventriculus junction was cut. The alimentary tract (from the proventriculus to the vent) was then removed from the carcass intact. The gizzard-duodenal junction was double clamped and then severed. Superficial fat surrounding the proventriculus and gizzard was removed, and the combined weight of the proventriculus and gizzard was recorded. The intestines (duodenum to cloaca, excluding the liver and spleen) including their contents were also weighed. The crop was excised after severing the spinal column at the shoulders and pulling the neck about 10 cm away from the carcass (Buhr et al., 2000; Buhr and Dickens, 2002). The crop was clamped at the junctions with the cervical and thoracic esophagus and then removed. The cervical esophagus was trimmed to a length equal to that of the thoracic esophagus (from the crop to the proventriculus), and the crop and contents were weighed. Eviscerated carcass weight was obtained after removal of the neck, heart, and reproductive tract but included the lungs and oil gland. Eviscerated carcass weight was used as a core weight in the calculation of percentage weights for the crop, proventriculus and gizzard, and intestine segments of the alimentary tract. From the 7 hens processed per treatment group, the first 6 that were in egg production that did not have retained eggs or fluid within the abdominal cavity were used for data collection.

Statistical Analysis

Data obtained were analyzed under the general linear models procedure of SAS software (SAS Institute, 1994). The main effects of the model were the comparison by time after feeding that hens were cooped (4 feeding times of 0, 2, 4, and 6 h for d 1 and 2) and 3 flocks (A, B, and C). Means were separated using Tukey's studentized range (HSD) test (SAS Institute, 1994). Orthogonal contrasts were used to determine significant linear relationships among hens processed on either d 1 or 2 and among hens cooped and processed at 0 h (that were not fed on d 1) and those hens that were fed on d 1 for 2, 4, or 6 h and processed on d 2. For all analyses, significance was determined at the $P < 0.05$ level.

RESULTS AND DISCUSSION

The weight of the hen, crop, and intestines differed ($P < 0.0001$) for the 3 flocks; however, the weight of the proventriculus and gizzard combined was similar (with

TABLE 1. Influence of time from last feeding and time cooped on hen weight at slaughter and on eviscerated carcass, crop, proventriculus and gizzard, and intestine weights, expressed as percentages of eviscerated carcass weight

Processing time after		Hen weight				Crop weight		Proventriculus and gizzard weight		Intestine weight	
Feeding (h)	Cooping (h)	Initial (g)	Slaughter (g)	Carcass (g)	Percentage (%)^{1}	(g)	(%)^{2}	(g)	(%)^{2}	(g)	(%)^{2}
Day 1											
0 (24)^{3}	0.25	3,797	3,705	2,491	65.5^{ab}	14.6^{b}	0.58^{b}	63^{bcd}	2.57^{bc}	166^{ab}	6.66^{ab}
2	0.25	3,740	3,666	2,492	66.6^{a}	69.8^{a}	3.02^{a}	71^{abc}	2.89^{ab}	176^{a}	7.13^{a}
4	0.25	3,783	3,714	2,475	65.4^{ab}	78.3^{a}	3.25^{a}	73^{ab}	2.99^{ab}	174^{a}	7.07^{a}
6	0.25	3,777	3,735	2,483	65.7^{ab}	95.1^{a}	3.98^{a}	78^{a}	3.22^{a}	176^{a}	7.11^{a}
Day 2											
0 (24)	26	3,751	3,510	2,396	63.8^{b}	12.4^{b}	0.52^{b}	54^{d}	2.31^{c}	140^{b}	5.87^{b}
2	24.5	3,803	3,585	2,424	63.7^{b}	11.8^{b}	0.49^{b}	62^{cd}	2.60^{bc}	162^{ab}	6.69^{ab}
4	23	3,788	3,589	2,403	63.4^{b}	14.2^{b}	0.59^{b}	63^{bcd}	2.66^{bc}	153^{ab}	6.38^{ab}
6	21.5	3,762	3,620	2,420	64.3^{b}	14.0^{b}	0.58^{b}	63^{bcd}	2.65^{bc}	157^{ab}	6.50^{ab}
Pooled SE		115	119	82	0.9	11	4.46	4	0.19	11	0.38
Source of variation		Probability									
ANOVA main effects											
Treatment		0.9973	0.2680	0.6321	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0007
Flock		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0644	0.0001	0.0001	0.0001
Trt × flock		0.9996	0.9983	0.9992	0.7910	0.0001	0.0001	0.4645	0.7662	0.5430	0.2084
Contrasts											
Day 1											
0 to 6 h		0.9567	0.6906	0.8679	0.7601	0.0001	0.0001	0.0001	0.0002	0.3792	0.2019
Day 2											
0 to 6 h		0.9488	0.2159	0.7726	0.6301	0.1645	0.1949	0.0084	0.0191	0.0912	0.1061
Day 1 0 h vs. Day 2 2 to 6 h		0.6300	0.3350	0.1792	0.0206	0.9082	0.6404	0.9338	0.4716	0.1569	0.4303

[a–d]Means within a column with no common superscript differ significantly ($P < 0.05$).

[1]Carcass weight expressed as a percentage of initial weight that was obtained 2 d prior to processing on d 1.

[2]Crop, proventriculus and gizzard, or intestine weight as a percentage of eviscerated carcass weight.

[3]Hens in the 0 (24) h group were not fed prior to catching and cooping on d 1.

minimum values of 43 to 46 g and maximum values from 93 to 108 g). Initial BW for flocks A, B, and C were 3.4, 3.9, and 3.7 kg, respectively. The only significant interaction detected between feeding time treatments and flocks was for crop weight (Table 1). Crop, proventriculus and gizzard, and intestine weights were combined for the 3 flocks and are presented as averages in Table 1; only the results for the crop are discussed by flock and presented in Table 2. In addition, the alimentary tract weight data were expressed and analyzed on a percentage of carcass weight basis, thereby standardizing the data for variation in carcass weight for the 3 flocks.

Hens processed on d 1 and 2 did not differ in average live weight at slaughter or eviscerated carcass weight across all feeding time treatment groups (within a flock or when combined for the 3 flocks) (Table 1). The absence of a difference in weight was expected and may be explained by the fact that groups were matched for initial weight prior to pen assignment, and the range in mean group weight was only 63 g, the weight of an extra-large egg. Eviscerated carcass weight expressed as a percentage of initial BW (obtained 2 d before d 1) averaged 64.2% with a range from 63.4 to 66.6%. Eviscerated carcass weight percentages were numerically greater on d 1 compared with percentages for those hens held overnight in coops without access to water and then processed on d 2, indicating about a 2% carcass shrink.

On d 1, crop and contents weight increased from an average of 15 to 95 g for hens processed at 0 and 6 h after feeding, respectively (Table 1). Hens from flock A obtained peak crop weight at 4 h, which had decreased 37 g (from a value of 145 to 108 g) by the 6 h cooping and processing time (Table 2). This more rapid crop filling for the flock A hens cannot be explained by the time of year (May compared with processing in September and January for hens from flocks B and C, respectively), and house temperature. Flock A hens had the lowest BW at 3.4 kg, which is about 200 g less than the 3.6-kg target weight for their age (Cobb-Vantress, 1998). Flock B and C hens were about 100 g above the target weights for their age. The more rapid feed intake for the flock A hens may be explained by the larger laying pens (7.3 × 9.1 m) and more hens within each pen (240 hens) and, therefore, greater competition for the limited feed when these hens were obtained. However, during the 2-wk preprocessing holding period, the hens used in these experiments were all housed in the same building in 2.4 × 3.6 m pens that are able to house 35 hens, but only 14 hens were held in each pen. The single tube feeder used in the current experiments enabled all 14 hens per pen to eat simultaneously.

TABLE 2. Influence of time from last feeding and cooping overnight on crop weight, expressed as a percentage of eviscerated carcass weight for hens from 3 flocks

Flock and time	Processing time after: Feeding (h)	Cooping (h)	Crop weight (g)	Crop weight (%)[1]
A				
Day 1	0[2]	0.25	12[b]	0.57[b]
	2	0.25	135[a]	6.22[a]
	4	0.25	145[a]	6.30[a]
	6	0.25	108[a]	5.08[a]
Day 2	0	26	12[b]	0.57[b]
	2	24.5	12[b]	0.54[b]
	4	23	11[b]	0.52[b]
	6	21.5	12[b]	0.57[b]
B				
Day 1	0	0.25	15[b]	0.58[b]
	2	0.25	29[b]	1.13[b]
	4	0.25	51[ab]	1.99[ab]
	6	0.25	91[a]	3.69[a]
Day 2	0	26	12[b]	0.47[b]
	2	24.5	12[b]	0.46[b]
	4	23	12[b]	0.48[b]
	6	21.5	15[b]	0.60[b]
C				
Day 1	0	0.25	17[b]	0.64[b]
	2	0.25	45[b]	1.70[b]
	4	0.25	39[b]	1.46[ab]
	6	0.25	86[a]	3.16[a]
Day 2	0	26	14[b]	0.53[b]
	2	24.5	12[b]	0.47[b]
	4	23	19[b]	0.76[b]
	6	21.5	16[b]	0.61[b]

[a,b]Values within flocks (A, B, or C) for crop weight with no common superscript differ significantly $P < 0.05$.

[1]Crop weight as a percentage of eviscerated carcass weight.

[2]Hens in the zero hour group were not fed prior to cooping on d 1.

On d 2, hens held overnight had an average crop weight of 13 g (ranged from 11 to 19 g) and did not differ among groups or when compared with the average crop weight of 15 g for hens processed on d 1 without feeding (Tables 1 and 2). Crop weight expressed as a percentage of eviscerated carcass weight revealed the same pattern as crop weight on d 1 and 2 (Tables 1 and 2). These results suggest that the crop is able to empty when hens are held overnight in coops without access to water to the level present in hens cooped and processed on d 1 prior to feeding (that had access to water).

Proventriculus and gizzard weight on d 1 increased from an average of 63 to 78 g for hens cooped at 0 and 6 h after feeding (Table 1). On d 2, hens held overnight had average proventriculus and gizzard weights ranging from 54 to 63 g. The 9 g of less weight (from d 1 to 2) for the hens cooped 0 h indicated continued emptying of the proventriculus and gizzard of contents (feed and litter) in the absence of access to water. The similar proventriculus and gizzard weight for the 3 remaining d 2 groups of hens averaged 62 to 63 g and suggested that hens processed on d 1 at 0 h had consumed minimal litter. These d 1 hens processed at 0 h had access to litter and water within the pen that was only limited by photoperiod, lights on at 0500 h and off at 1900 h. Proventriculus and gizzard weight expressed as a percentage of eviscerated carcass weight revealed a difference among flocks ($P < 0.0001$) but no interaction between flocks and feeding treatments times ($P > 0.7662$).

Intestine weight did not differ among hens processed on d 1 or 2 (Table 1). Intestine weight on d 1 increased only up to 10 g for hens cooped 2, 4, or 6 h after feeding (from 166 to 176 g). On d 2, hens held in coops overnight had average intestine weight range from 140 to 162 g. Only when values between d 1 and 2 were compared was a significant difference detected. Hens processed on d 2 that were cooped prior to the daily feeding had the lowest average intestine weight at 140 g, 5.87% of carcass weight. This result indicates that the intestines continued to decrease in weight by voiding their contents while hens were cooped overnight without access to water.

This overall pattern of alimentary tract segment weights suggests that, during meal feeding, feed passes rapidly to the intestines and then begins to accumulate in the proventriculus and gizzard and finally in the crop. This late accumulation in the crop may be the result of additional water intake during or following the feeding. For hens processed after being held in coops overnight, tract segment weights did not differ among hens at any cooping time for the crop, proventriculus and gizzard, or intestines. Clearance of the crop and proventriculus readily occurred overnight, whereas hens were held in coops without access to water. However, not until after 50 h off feed and 26 h off water had the intestines attained the lowest value (140 g).

These results demonstrate that cooping broiler breeder hens at 0, 2, 4, or 6 h after a limited morning feeding resulted in comparable alimentary tract clearance when hens were processed the following morning. In addition, an average crop weight of 13 g was attained for hens in all groups when held in coops overnight. This finding suggests that when crops full of feed are encountered during the processing of hens, it is likely that the hens were processed on the same day they were cooped.

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